(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 339 825 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **89303610.3**

(51) Int. Cl.4: **E21B 47/12**

(22) Date of filing: **12.04.89**

The title of the invention has been amended (Guidelines for Examination in the EPO, A-III, 7.3).

(30) Priority: **29.04.88 US 188958**

(43) Date of publication of application:
02.11.89 Bulletin 89/44

(84) Designated Contracting States:
AT BE CH DE ES FR GB GR IT LI LU NL SE

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(54) Apparatus for data transmission in a borehole.

(57) Apparatus in which a boring tool (12) is urged through the ground by means of a drill string (14) in order to form an underground hole (18) includes an arrangement for obtaining certain information at the boring tool (12) during operation of the latter, the arrangement including a transducer (26) carried by the boring tool (12) for generating an AC signal containing desired information and means for connecting the transducer directly to the drill string and to the surrounding ground for transmitting the information containing signal to an above ground location (38).

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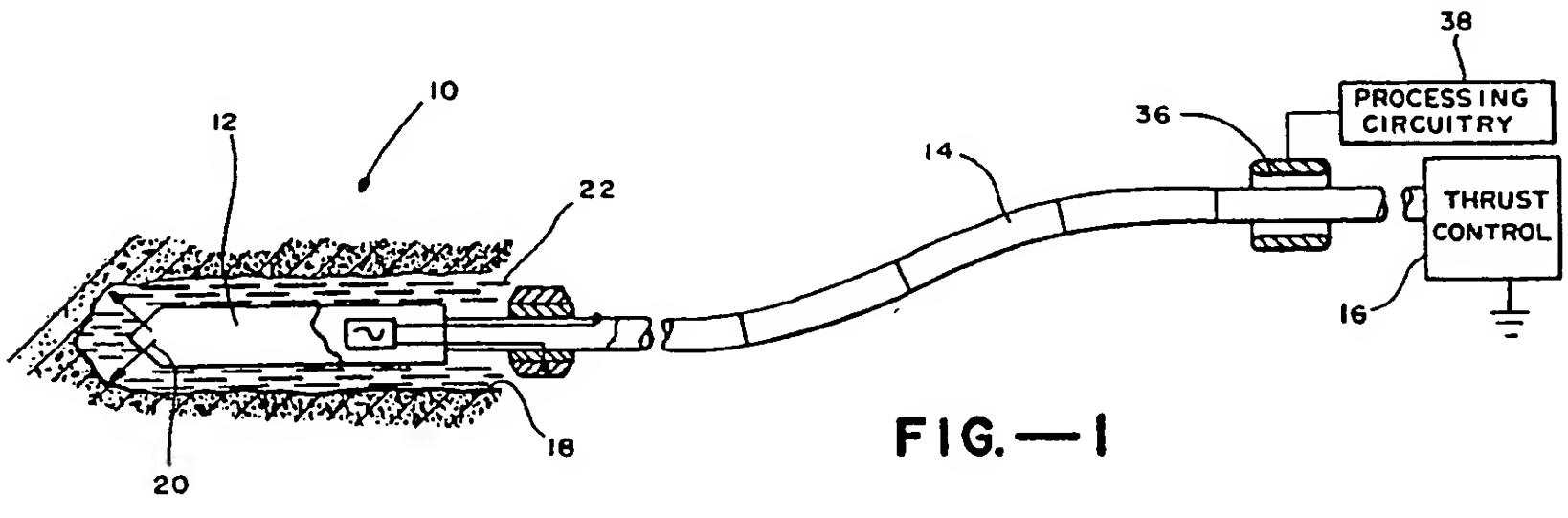

FIG.—1

BORING APPARATUS

The invention relates to boring apparatus.

The concept of providing real time transmission of information taken at a boring tool as the latter is used to drill a hole in the ground is well known in the art. This concept is frequently referred to as 'Downhole Measuring While Drilling' or simply 'Measuring While Drilling' (MWD). An excellent discussion of this concept and a number of different approaches appears in US-A-4348672.

Two principal functions to be performed by a continuous MWD system are downhole measurements and data transmission. In the case where data is gathered by a transducer which generates an AC signal containing the desired data, one way to transmit the signal to gorund level from the boring device where the signal is generated is to use the co-operating drill string as the conductor, assuming of course that the drill string body defines a continuous electrically conductive path to ground level. A typical way in which the AC signal is first coupled to the drill string from the boring device and the way that it is typically decoupled from the drill string at ground level is by means of inductive coupling utilising, for example, a toroidal transformer. While this technique presents no serious problems at ground level where there is sufficient room, a toroidal transformer or other such inductive means is quite difficult to use within the confines of the hole being drilled.

According to this invention there is provided boring apparatus including a boring tool designed to bore a hole through the ground, a drill string connected at one end with said boring tool and extending from there to ground level through the hole being formed, means for urging the boring tool and drill string forward as the hole is being made, information providing means carried by said boring tool for generating an AC signal containing certain inground information between a pair of output terminals, and transmitting means for transmitting said information containing signal to an aboveground location where said information can be extracted from the signal, characterised in that said transmitting means includes the ground surrounding the boring tool as the latter moves through the hole being formed, at least a section of said drill string which is sufficiently electrically conductive to carry said signal, means for electrically connecting one of said pair of output terminals of said information providing means to said section of said drill string, and means electrically insulated from said drill string section for connecting the other of said output terminals to said ground surrounding said boring tool, whereby said drill string section serves to carry said AC signal and said surrounding ground is used as a signal return path.

The invention provides an apparatus of the general type described above, but in which the AC signal is not inductively coupled to the co-operating drill string within the inground hole, but rather is coupled by a much less complicated and just as reliable coupling technique.

The invention will now be described by way of example with reference to the drawing, in which:-

Figure 1 diagrammatically illustrates an apparatus in accordance with the invention for transmitting, in real time, data from a boring tool to an above ground location;

Figure 2 is a diagrammatic illustration of the data transmission arrangement forming part of the overall apparatus shown in Figure 1;

Figures 3 and 4 are diagrammatic illustrations of two modified real time data transmission arrangements which could be utilised with the apparatus of Figure 1; and

Figure 5 shows an alternative apparatus for use in wet or dry soils which employs a capacitive coupling capability.

Turning now to the drawings wherein like components are designated by like reference numerals in the figures, attention is first directed to Figure 1 which, as stated above, diagrammatically illustrates an overall boring apparatus.

The apparatus which is generally indicated by the reference numeral 10 includes a boring tool 12 and drill string 14 which, for example, may be of the type described in US-A-4674579. The boring tool described is connected to one end of the drill string and both are urged forward through the soil by a suitable thrust-providing device located above ground. In Figure 1 a corresponding thrust device and associated controls for operating the entire apparatus are generally indicated at 16. It is to be understood that the apparatus of the invention does not require any particular boring device, drill string, or any particular thrust providing device and controls.

Still referring to Figure 1, boring tool 12 is shown in operation boring through the soil, thereby forming an inground hole 18. In the particular embodiment illustrated, the boring tool utilises fluid cutting jets 20 for cutting through the soil and therefore the hole surrounding the boring tool fills up with cutting or drilling fluid which is generally indicated at 22.

Turning to Figure 2 in conjunction with Figure 1, attention is now directed to an arrangement 24 for gathering inground information at the boring tool and for transmitting the information in real time.

that is, as the information is being gathered, to an above ground location where the information is retrieved and processed. Arrangement 24 includes a transducer 26 or other such information providing means carried by the boring tool for generating an AC signal containing the information desired. One example of an information providing means is a rotation transducer. Other such means could include other types of position or orientation transducers or other data acquisition devices so long as the particular information is encoded and converted to an AC signal containing the particular information being generated.

For purposes of convenience, in the following description, it will be assumed that means 26 is a rotation transducer with suitable electronics for producing an AC signal containing information about the rotational position of boring device 12 at any given point in time. As illustrated in Figure 2, the AC signal is produced across two output terminals 28 and 30. In an actual working embodiment, the AC signal operates at a frequency range of approximately 1 kilohertz to 100 kilohertz with a signal amplitude of approximately a few millamperes.

Arrangement 24, like many prior art approaches, utilizes a continuous section of drill string 14 to carry its information containing AC signal to ground level where it can be retrieved and processed. To that end, the drill string or at least a continuous section intended to carry the signal is sufficiently electrically conductive to do so.

However, as indicated above, in the past the AC signal was typically inductively coupled to the inground end of the drill string by a suitable transformer assembly.

The AC signal from transducer 26 is not inductively coupled to the drill string but rather directly coupled thereto. More specifically, as illustrated best in Figure 2, one of the two output terminals of transducer 26, for example, terminal 28, is physically connected to the drill string (e.g. the electrically conductive section). At the same time, the other output terminal, for example terminal 30, is grounded so that the drill string section serves to carry the AC signal while ground serves as a signal return path. In the particular embodiment illustrated, terminal 30 is physically connected to an electrically conductive collar 32 which extends around the electrically conductive section of drill string 14 but which is electrically insulated from the drill string by a suitable dielectric layer 34. However, the electrically conductive collar is located adjacent boring device 12 and therefore is in contact with the cutting fluid 22. Thus, the electrically conductive collar and therefore terminal 30 are grounded through the drilling fluid and the surrounding ground wall defining hole 18.

The AC signal from transducer 26 is carried up the drill string to ground level where it is inductively retrieved by a suitable transformer generally indicated at 36. In an actual working embodiment, transformer 36 is a toroidal transformer consisting of approximately 100 turns of wire. Suitable signal processing circuitry generally indicated at 38 is used to process the retrieved signal so as to retrieve the information contained within the signal. It is to be understood that transformer 36 and processing circuitry 38, like most of the other components of the overall apparatus, are readily providable by those with ordinary skill in the art and, hence, will not be described herein.

Arrangement 24 forming part of the overall apparatus 10 was described above including the insulated collar 32 exposed to drilling fluid in order to ground output terminal 30 and thereby provide a signal return path through the cutting fluid and the surrounding ground. It is to be understood that the collar itself can be placed in any suitable convenient position so long as it is electrically insulated from the drill string section carrying the signal and so long as it is indirect contact with the ground or exposed to the cutting or drilling fluid or sufficiently close to the ground to capacitively couple the signal. For example, it could be grounded to or part of the outer body of the boring head itself as long as the boring head body is electrically conductive and meets these other requirements. An entirely different means for grounding terminal 30 can also be provided, as exemplified in Figures 3,4, and 5 to be discussed immediately below.

Turning first to Figure 3, arrangement 10' is shown. This arrangement may be identical to arrangement 10, except for the way in which terminal 30 of its transducer 26 is grounded and, possibly, the particular boring tool used. At the outset, it should be noted that arrangement 10' includes a boring tool 12', for example, an impact device, having an outer body constructed of an electrically conctive material, for example steel, electrically connected to a front section 14A of drill string 14 and electrically insulated from the rest of the drill string by a suitable dielectric separator generally indicated at 40. Terminal 28 is connected to the drill string in the manner described above. However, terminal 30 is connected directly (physically) to the outer electrically conductive housing of boring tool 12', or as shown in Figure 3 to the electrically connected drill string section 14A, thus eliminating the utilization of collar 32 and associated insulation layer 34. Thus, as the boring tool forms hole 18 it engages drilling fluid, if any is present, thereby grounding terminal 30 in the same manner as collar 32. On the other hand, if the boring tool does not rely on fluid cutting jets in the manner described above, but rather continuously engages the end of the hole, as shown in Figure 3,

than the direct engagement between the boring head and the soil serves as the desired ground.

In Figure 4, apparatus 10" is shown and may be identical to apparatus 10 or 10' except for the way in which output terminal 30 of transducer 26 is grounded. In the case of apparatus 10", an insulated collar 42 is disposed around the drill string and carries with it electrically conductive rollers 44 spring biased against the side wall of hole 18 so as to define ground path from terminal 30 through the collar, cooperating biasing spring arms 46 and rollers 44. One or more spring bias rollers may be utilized.

Figure 5 shows a tool head 50 which has a large forward head section 52 displaying a large surface area for direct contact with the soil 51. Forward section 52 is electrically isolated from pipe 53 by means of insulator 54. Head section 52 can be used for boring with or without bentonite or water. Its principal of operation is as follows. The thrust force on the drill pipe 53 makes the tool head 52 come into contact with the soil surrounding the tool head. In the event that the soil is very dry or very low in conductivity, the capacitance between the relatively large surface area of the tool head 52 and the soil can become the dominant means of signal flow from the tool head to the surrounding soil. Once the signal is coupled into the ground the remaining signal flow is the same as previously described. Note specifically that one terminal 56 at the output of transducer 58 is connected to the drill pipe 53 while the other terminal 60 is connected to head section 52. This embodiment is to be contrasted with apparatus 10" in Figure 4 where there is direct contact between rollers 44 and the soil. The surface area of the rollers is small compared to the surface area of head section 52 of tool head 50 and there is little capacitive coupling.

Claims

1. Boring apparatus including a boring tool (12, 50) designed to bore a hole (18) through the ground, a drill string (14, 53) connected at one end with said boring tool (12, 50) and extending from there to ground level through the hole being formed, means (16) for urging the boring tool (12, 50) and drill string (14, 53) forward as the hole is being made, information providing means (26, 58) carried by said boring tool (12, 50) for generating an AC signal containing certain inground information between a pair of output terminals (28, 30; 56, 60), and transmitting means for transmitting said information containing signal to an above-ground location (38) wherin said information can be extracted from the signal, characterised in that said transmitting means includes the ground surrounding the boring tool as the latter moves through the hole being formed, at least a section of said drill string (14, 53) which is sufficiently electrically conductive to carry said signal, means for electrically connecting one (28, 56) of said pair of output terminals of said information providing means (26, 58) to said section of said drill string (14, 53), and means (32, 42, 44, 52) electrically insulated from said drill string section (14, 53) for connecting the other (30, 60) of said output terminals to said ground surrounding said boring tool (12, 50), whereby said drill string section (14, 53) serves to carry said AC signal and said surrounding ground is used as a signal return path.

2. Apparatus according to Claim 1, characterised in that said boring tool (12) utilises a drilling fluid (22) during formation of said hole (18) such that the drilling fluid (22) surrounds the tool (12) within the hole (18), said electrically insulated means (32) being connected to said other output terminal (30) and positioned to contact directly the drilling fluid (22) surrounding the boring tool (12) thereby to connect said other output terminal (30) to the surrounding ground.

3. Apparatus according to Claim 1, characterised in that said boring tool (12') includes an outer body section electrically insulated from said drill string section (14), said other output terminal (30) being electrically connected with said outer body section (12') which serves as said electrically insulated means for connecting said other output terminal (30) to the surrounding ground.

4. Apparatus according to Claim 3, characterised in that said drill string (14) includes a second section electrically insulated from said first-mentioned section (14A), said other output terminal (34) being electrically connected directly to said second drill string section.

5. Apparatus according to Claim 3, characterised in that said outer body section (52) of said tool (50) includes a sufficiently large outer surface so as to capacitively couple said other output terminal to the surrounding ground in the event the ground is very dry or very low in conductivity.

6. Apparatus according to Claim 1, characterised in that said electrically insulated means (44) includes means connected to said other output terminal (30) and engaging the wall defining said hole.

7. Apparatus according to any preceding claim, characterised in that said information providing means (26, 58) comprises a rotation transducer.

8. Apparatus according to any preceding claim, characterised by processing means (36, 38) located at said above ground location for acting on said AC signal and extracting said information therefrom.

9. Apparatus according to Claim 8, characterised in that said processing means includes inductive coupling means (36) located around said drill string (14) at said above ground location.

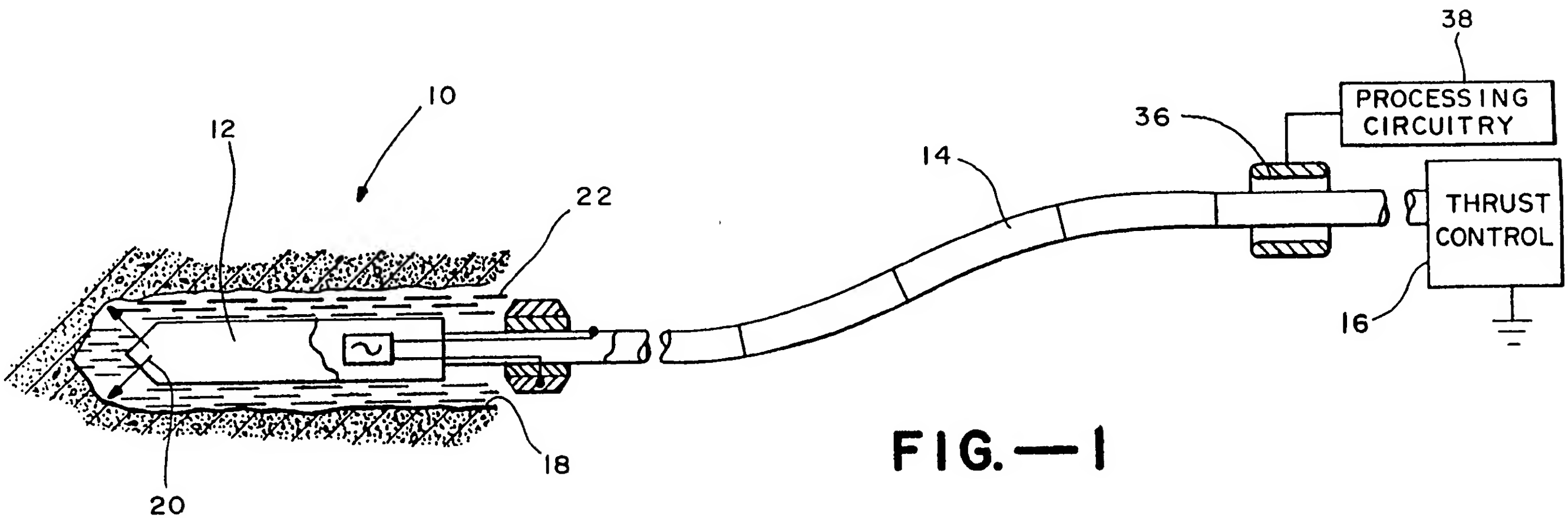

FIG.—1

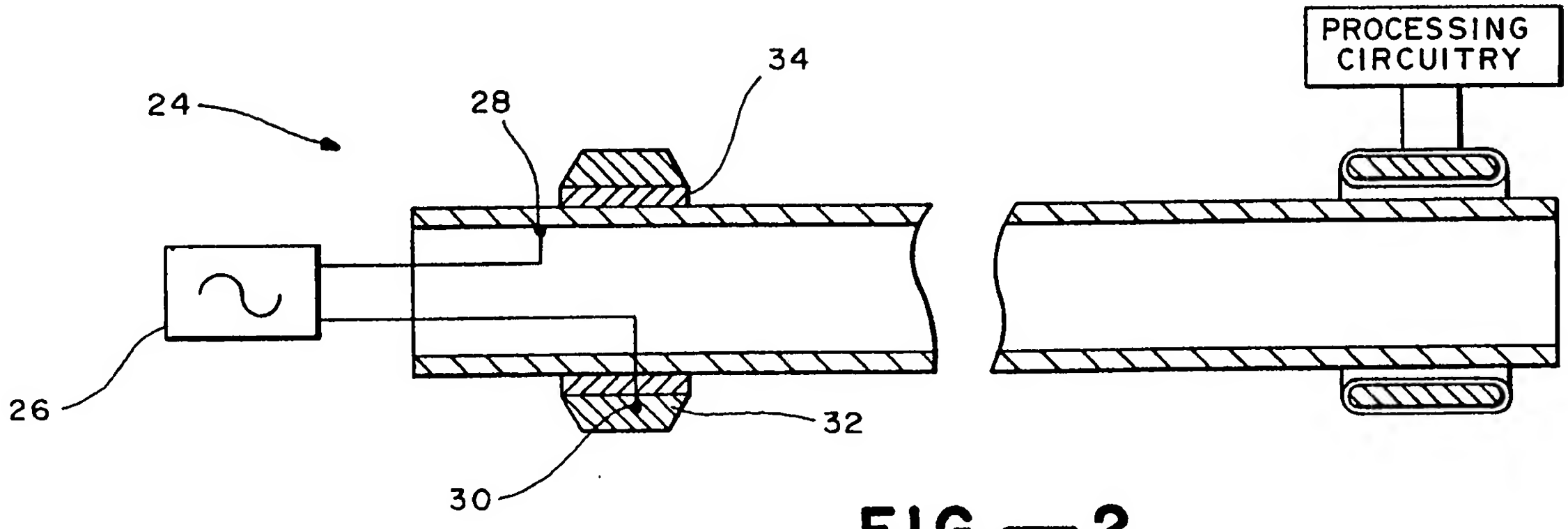

FIG.—2

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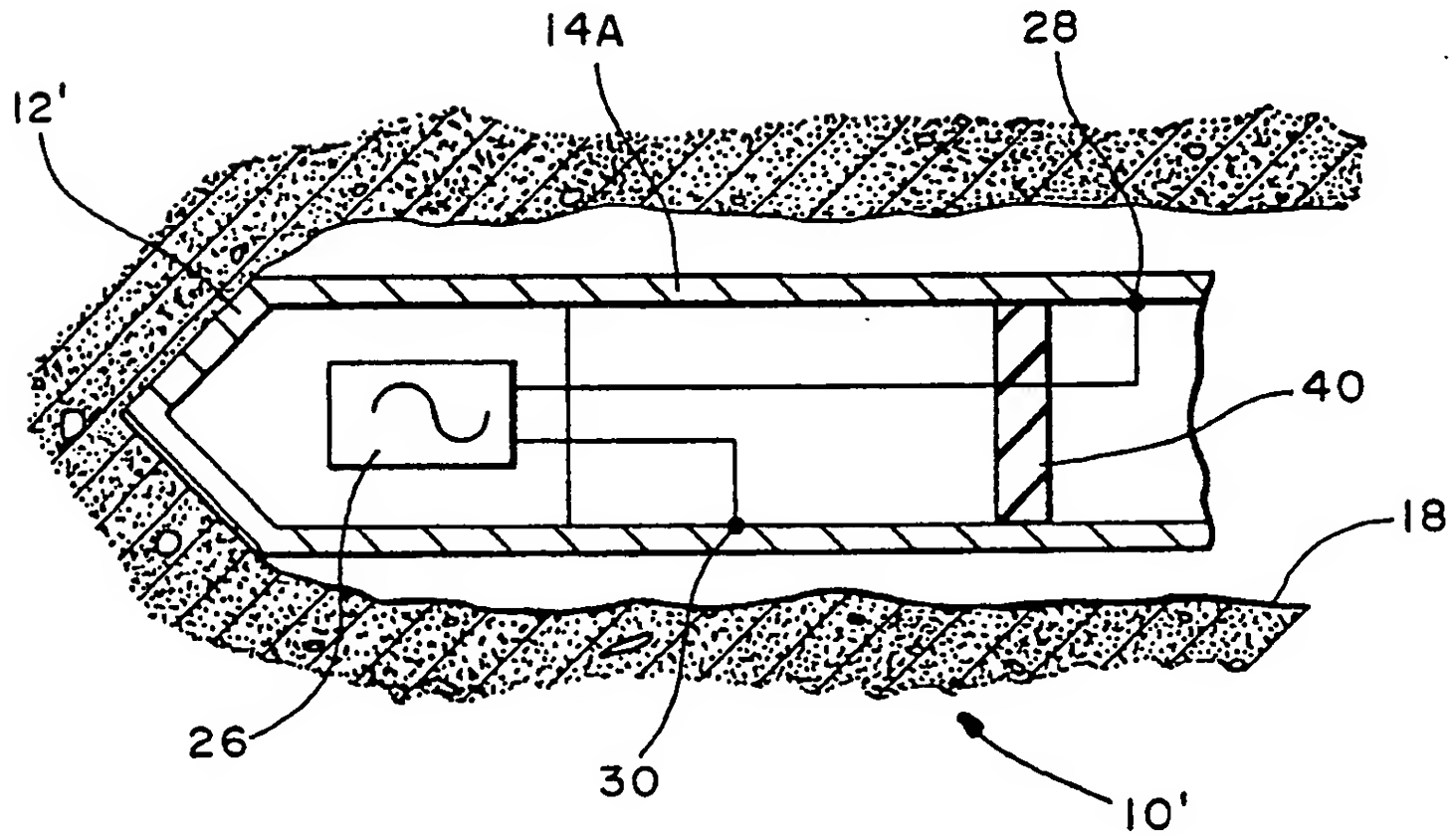

FIG. — 3

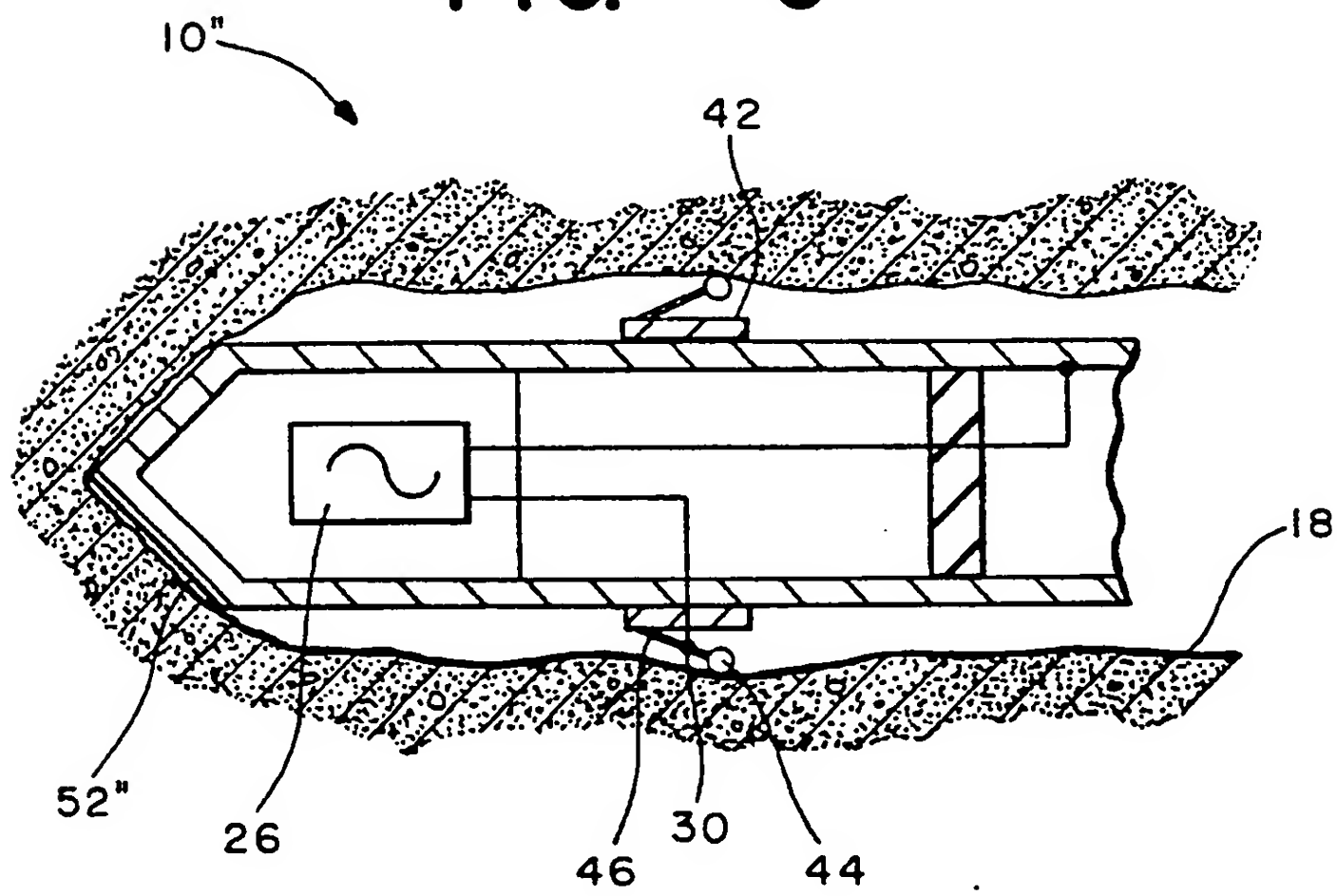

FIG. — 4

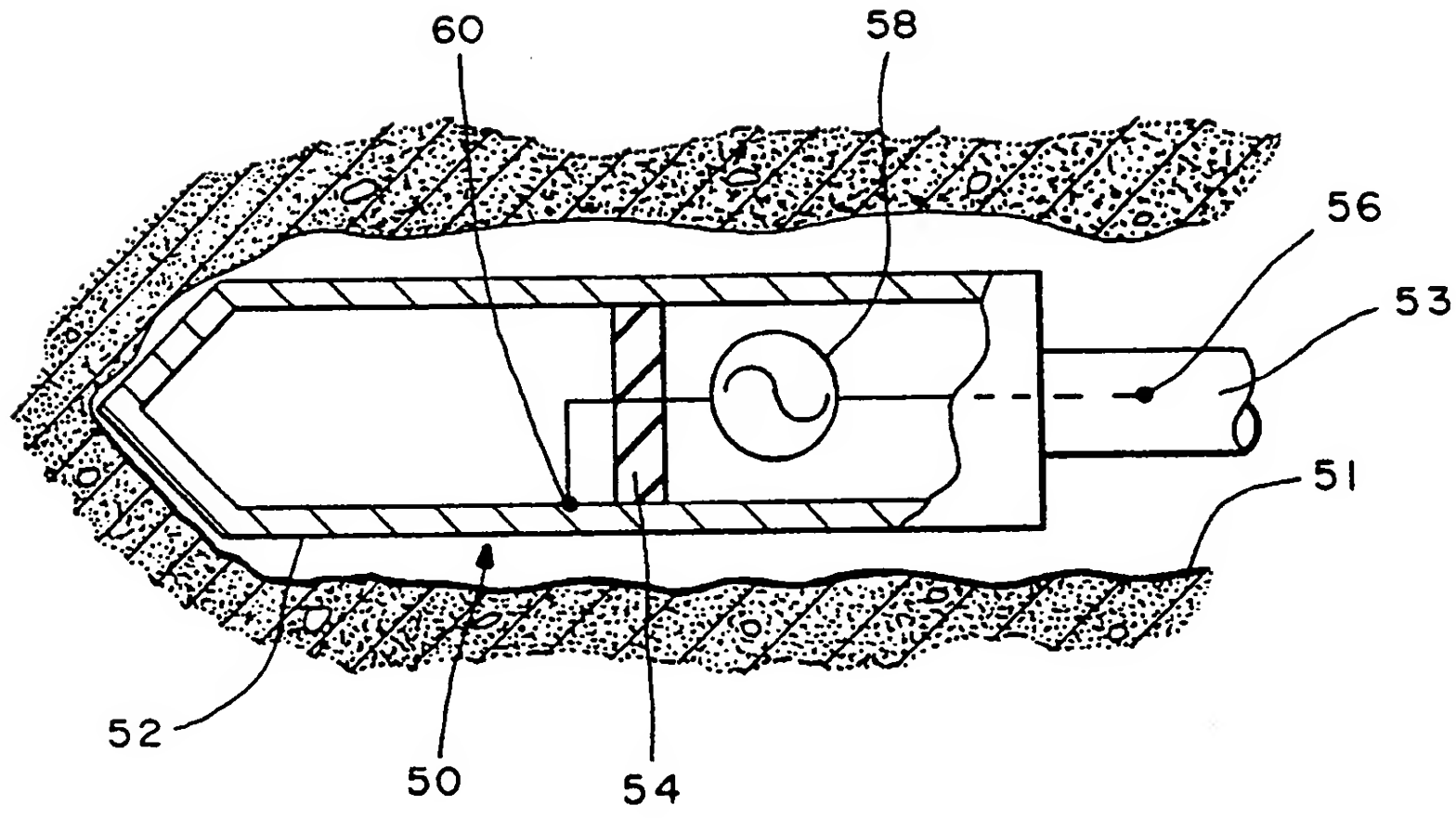

FIG. — 5

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EUROPEAN SEARCH REPORT

Application Number

EP 89 30 3610

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	GB-A-2 083 321 (THE MARCONI CO.) * Page 1, lines 5-9,65-88; page 1, line 120 - page 2, line 6; page 2, lines 20-24; figure 1 *	1,3-5,7-8	E 21 B 47/12
Y		2,6	
Y	US-A-3 186 222 (P. MARTIN) * Page 3, lines 18-61; figure 1 *	2	
Y,P	US-A-4 747 451 (H. ADAMS et al.) * Column 5, line 29 - column 6, line 13; column 5, line 37 - column 6, line 30; figure 2A *	6	
X	US-A-4 691 203 (L.A. RUBIN et al.) * Column 1, lines 14-64; column 3, lines 36-46; column 4, lines 13-29; column 4, line 63 - column 5, line 25; figures 1,2 *	1	
A	US-A-4 716 960 (B.J. EASTLUND et al.) * Column 7, line 16 - column 8, line 22; figure 5A *	6	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	DE-A-2 848 722 (SPERRY RAND CORP.) * Page 6, last paragraph - page 7, paragraph 1; page 8, last paragraph - page 9, paragraph 1; figure 1 *	2	E 21 B
A	WO-A-8 000 727 (S.A. HORCHLER) * Page 1, lines 2-9; page 5, lines 11-37; page 7, lines 21-31; figures 1,6 *	6	
A	DE-B-2 818 004 (FUNKE + HUSTER)		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	07-07-1989	RAMPELMANN K.

EPO FORM 1503 03.82 (P0401)

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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